# STRATIGRAPHY, PALYNOLOGY AND IMPLICATIONS OF ORGANIC BANDS IN A SMALL QUATERNARY BASIN, NEAR PALMER, SOUTH AUSTRALIA†

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**Summary**

GRUBB, E. A. A. (1978) Stratigraphy, palynology and implications of organic bands in a small quaternary basin, near Palmer, South Australia. *Trans. R. Soc. S. Aust.* **102**(5), 117-123, 30 August, 1978.

The stratigraphy and pollen content of dominantly sandy sediments in a creek bed near Palmer have been examined. Organic bands appear to reflect the presence of permanent standing water in a settling pond from about 8000 years B.P. to some time more recent than 6600 B.P. The generic content of the vegetation then was comparable to the present, but the presence of spores of Anthocerotales suggests that the climate was slightly wetter.

## Introduction

An intermittently flowing stream 11 km south of Palmer, South Australia, has deeply incised earlier deposits, exposing organic layers in its steep banks. The site is interesting because it is the only known Holocene site containing organic sediments in the Mt Lofty Ranges. It is critically positioned near the eastern limits of the Ranges, in a boundary zone between the woodland and open forest vegetation characteristic of the higher and wetter ranges to the west and the scrub and mallee, common on the Murray Plains in the east.

This paper describes the stratigraphy and gives pollen counts from the organic sediments, and discusses the implications of these results in the light of work done on material of comparable age from other parts of southern Australia.

Gorge Creek, lat. 34°55'S, long. 139°10'E, flows in a shallow valley running east from Mt Beevor towards the Murray Plains (Fig. 1). Mt Beevor is 480 m high, and is a spur of the higher and wetter Mt Lofty Ranges. Above the site, which is at an altitude of 200 m, the creek drains an area approximately 8 km long and at the most 3 km wide. Below the site the valley is constricted by rocky outcrops and the creek runs to the Murray Plains 3 km away through a narrow pass between the hills, which form the eastern-most edge of the Mt Lofty Ranges.

The mean annual rainfall is estimated as about 400 mm. Daily mean maximum temperatures at nearby Murray Bridge range from 28.9°C in February to 15.8°C in July, and daily mean minima from 15.1°C (February) to 5.5°C (July). It is likely that similar temperatures are experienced at the site, modified a little by the constricted valley formation of the surrounding hills which probably tend to trap cold air. Prevailing winds are from the west and southwest.

## Stratigraphy

A stratigraphic section (Fig. 2) was determined from natural exposures in the steep-banked gully of Gorge Creek. The deposit is about 100 m long; its breadth is uncertain but appears to be about 15 m. Alternating bands of sand and organic matter are about nine m thick (Fig. 3). The lower and more richly organic bands form discrete layers, but the upper bands are less rich and less distinct. Upstream and downstream there is a uniform brown sand which fills the bulk of the valley floor. Schist of the Kanmantoo group lies only a few centimetres below the present stream

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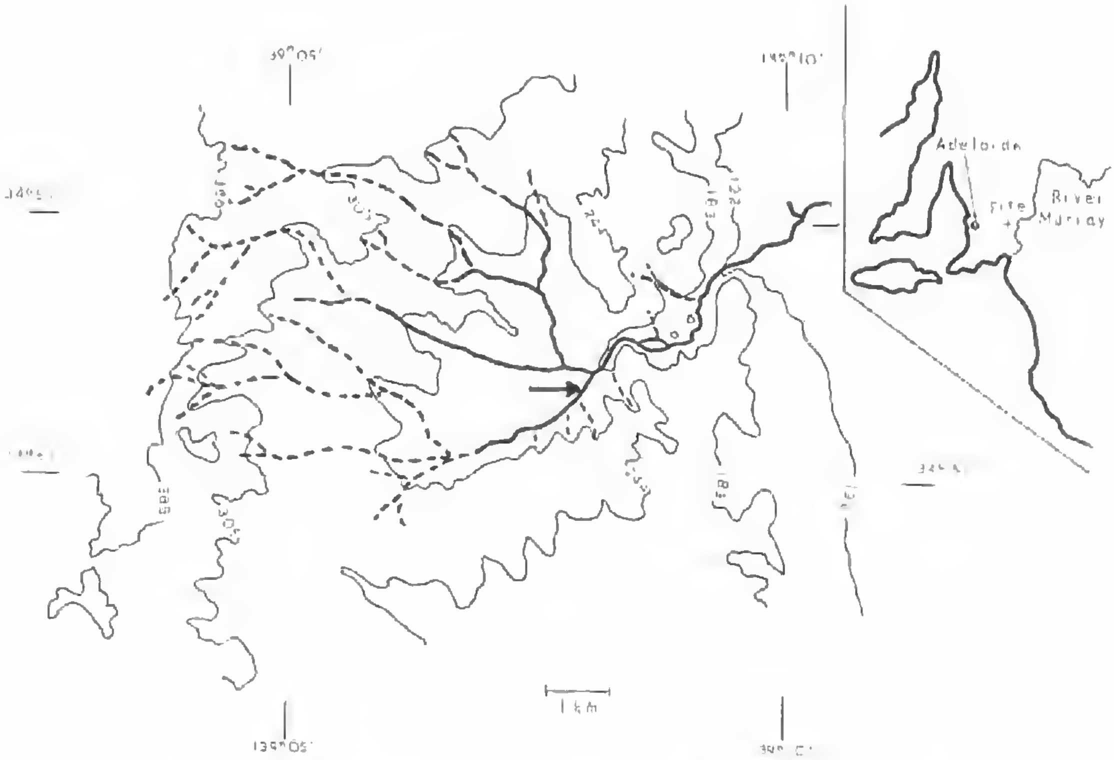

Fig. 1. Topography of upper reaches of Gorge Creek, showing position of deposit (arrowed). Palmer is 11 km to the north.

bed along the whole length of the deposit, and there is a particularly notable outcrop near the downstream end. It seems most likely that the deposit began to accumulate in a small waterhole or swamp retained behind a barrier formed by the schist. However, the deposit now extends over the schist barrier. Subsequent incision by Gorge Creek has formed a narrow, steep-banked gully, exposing the layers shown in Fig. 3.

The sands are of varying colour and texture, ranging from white through various shades of yellow, orange and brown to black organic sands and through fine and coarse sand to gravel (Fig. 2). Very little clay is present. The organic layers range from the black sand to a heavy moist peat-like material. There is no evidence of charcoal. The richest organic layers have been numbered one to seven (Fig. 2), and examined for the presence of pollen.

Two radio carbon dates were obtained. The oldest organic layer (7) was dated at 6600 ± 100 years B.P. A date of 8000 years was obtained for a more recent layer, and this makes it difficult to say with certainty when the earliest sedimentation occurred.

## Methods

Samples were collected from each organic layer. As the layers were exposed sands were simply sampled using 2.5 x 5 cm glass vials. Slabs of the peat-like layers approximately 20 x 20 cm, were removed and transported in plastic bags; in the laboratory fresh surfaces were exposed and subsampled for analysis.

Subsamples of 1 g were processed using standard techniques given by Faegri & Iversen (1950). The most satisfactory means of preparation was treatment with 5% potassium hydroxide for 15 min., followed by acetolysis and vibration using a 'vibraflute' (Tshudy 1960). The dehydrated residues were mounted in glycerine jelly and stained with safranin.

A reference collection was made of the pollen grains of about 200 species commonly found in the Palmer area now. Spores proved to be common in the deposit and this necessitated a small collection of fern and bryophyte spores as there was at that time no suitable reference text for these species in Australia.

## Vegetation of the study area

Specht (1972) has mapped the probable pre-settlement vegetation of the Palmer area as 'woodland to open-forest with herbaceous understorey' dominated by *Eucalyptus camaldulensis* (mainly in the valley bottoms), *E. odorata* and *Casuarina stricta*. The area was opened up for European settlement about 1850 and has been extensively cleared to leave an open grassland with occasional scattered trees. Within 2 km of the site can be found *Banksia marginata*, *Callitris collumellaris*, *C. preissii*, *Casuarina stricta*, *Eucalyptus anceps*, *E. camaldulensis*, *E. fasciculosa* and *E. porosa*. In most of the area the commonest trees are eucalypts, but on the rocky slopes surrounding the study site *Casuarina stricta* is relatively more prominent. The mallee eucalypts (*E. anceps* and *E. porosa*) occur in discrete outliers on sandy or rocky soils.

Native shrubs and sub-shrubs have been largely eaten out but some species may be found still: *Acacia* spp., *Billardiera sericophora*, *Bursaria spinosa*, *Correa schlechtandelii*, *Dodonaea viscosa*, *Haloragis heterophylla*, *Melaleuca neglecta*, *Olearia* sp., *Pimelea stricta*, *Rhagodia nutans*, and several small legumes. Three ferns found commonly are *Cheilanthes tenuifolia*, *Pleurosorus rutifolius* and *Pteridium esculentum*.

Within 1 km of the deposit are pools containing *Potamogeton crispus* and *Ruppia maritima*, and in the areas surrounding them grow *Carex tereticaulis*, *Juncus* sp., *Lepidosperma laterale*, *Leptocarpus brownii*, *Machaerina juncea*, *Scirpus americanus* and *S. nodosus*. In other areas probably seasonally waterlogged can be found *Cyperus gymnocaulos* and *Juncus* spp.

Nomenclature follows Black (1943–57) except where revised by Eichler (1965).

### The pollen record and its evaluation

Layer 1, an organic sand, and layer 2, an organic layer whose stratigraphic origins are obscure, yielded no pollen. Layers 3, 5, 6 and 7 contained pollen in meagre quantities, the average slide having a count of about 100 pollen grains. Layer 4 appeared as richly organic as these four, but the average pollen count was only 1 or 2 grains per slide, and it was decided to ignore it. However, it was quite rich in diatom skeletons and a small circular scale, possibly also of diatom origin (?*Melosira*, David Thomas, pers. comm.).

The pollen counts obtained are given in Tables 1 and 2. Because of difficulties experienced in trying to concentrate the pollen, I have included in Table 1 total counts of all

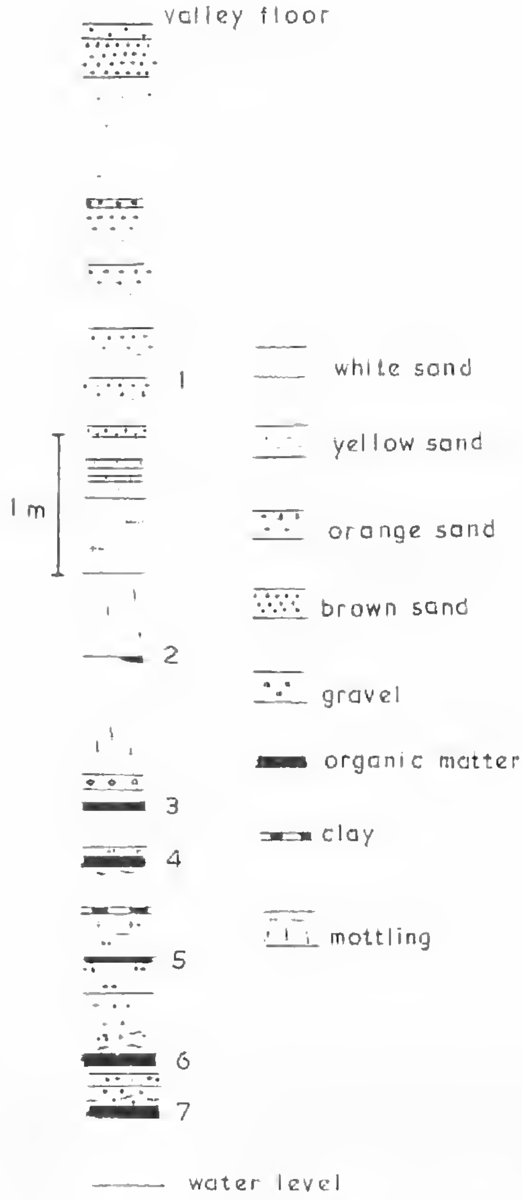


Fig. 2. Diagrammatic representation of sediments in deposit, showing organic coloured sands at top, mottled white sands in middle and organic bands containing pollen near base. Layers sampled for pollen analysis are numbered (and their thicknesses indicated below in parentheses): 1, very sandy, no pollen; 2, richly organic, but stratigraphically obscure, no pollen; 3, richly organic, pollen present (5 cm); 4, richly organic but very little pollen (7 cm); 5, (4 cm); 6, (7 cm) & 7, (5 cm), richly organic, pollen present. Depth of section about 8 m.

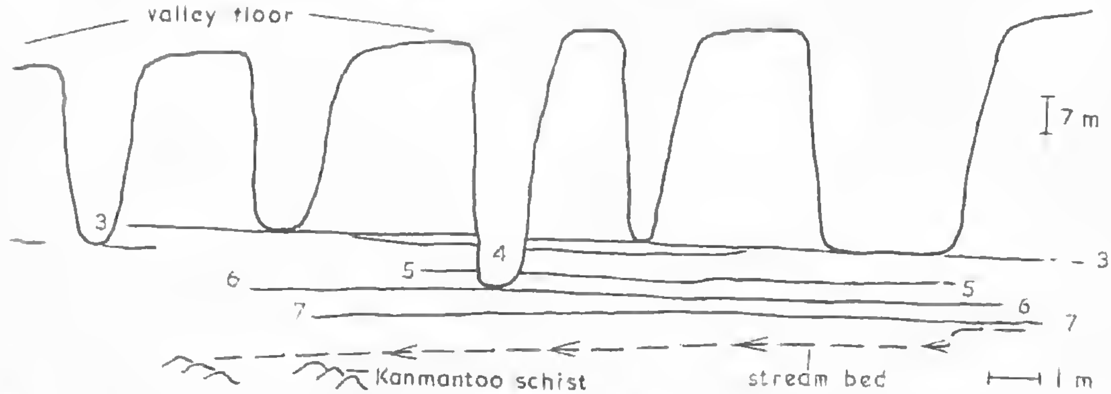


Fig. 3. Vertical section of east bank of Gorge Creek from valley floor to stream bed, showing extent of organic deposits. Organic sands are visible for further 26 m downstream. At the left is shown outcrop of Kanmantoo Schist which probably formed a barrier behind which deposit accumulated.

TABLE 1

*Pollen counts from layers 3, 5, 6 and 7 (different forms in descending order of prevalence).*

| Abundant forms Layer | 3 | 5 | 6 | 7 |
|---|---|---|---|---|
| Number of slides counted | 10 | 29 | 13 | 10 |
| *Casuarina* | 319 | 922 | 278 | 24 |
| Compositae Ia† | 89 | 96 | 30 | |
| Ib | 48 | 21 | 6 | 10 |
| 2 (Liguliflorae) | 21 | 6 | 1 | 3 |
| Chenopodiaceae | 44 | 45 | 44 | 8 |
| Haloragaceae | 58 | 45 | 13 | 6 |
| Gramineae | 22 | 35 | 29 | 9 |
| *Banksia* | 37 | 18 | 3 | 3 |
| Myrtaceae | 6 | 10 | 5 | 0 |
| Spores | 24 | 16 | 3 | 3 |
| Unknowns | 343 | 560 | 250 | 94 |
| Rare forms | | | | |
| Callitrichaceae | + | — | + | — |
| Caryophyllaceae | + | — | + | — |
| Centrolepidaceae | + | — | — | — |
| Convolvulaceae | + | — | — | — |
| Cruciferae | — | — | + | — |
| Cyperaceae | ? | ?+ | ? | ? |
| Droseraceae | + | — | — | — |
| Geraniaceae | + | + | — | — |
| Hydrocharitaceae | — | + | + | — |
| Labiatae | + | — | — | — |
| Leguminosae—*Acacia* | + | — | — | + |
| —Papilionatae | + | + | + | — |
| Liliaceae | + | — | + | — |
| Potamogetonaceae | — | — | + | — |
| Ranunculaceae—*Clematis* | — | — | + | — |
| Rutaceae | + | + | — | + |
| Thymelaeaceae—*Pimelea* | + | + | + | — |
| Typhaceae—*Typha*-like | — | + | +* | — |
| Umbelliferae | — | + | + | — |
| Diatoms | + | + | + | — |

* Ia *Helipterum*, *Helichrysum*, *Olearia* type pollen. Ib Others.
† Very numerous.

slides examined from each layer and, to get some sort of comparison between the layers, I have listed in Table 2 percentage representation of pollen from 10 slides from each layer, It is clear that the number of pollen present per slide varies markedly, but the commonest families are present in all layers. The unknowns, which made up 30–60% of the counts, appeared to be mostly Cyperaceae and Juncaceae. Both these families have thin-walled pollen grains with indistinct markings, and can easily suffer damage and distortion due to partial drying out.

The identification of the pollen to species level was not possible. Many of the genera represented are widespread and contain several species which have very similar pollen and distributions. Conversely, the pollen from the deposit was similar to, but not identical with locally abundant species. The possibility of species evolution as well as movement or migration needs to be borne in mind.

*Casuarina*-type pollen is by far the most abundant tree or shrub pollen in the deposit. There are three species of the genus currently found in the southern Mt Lofty Ranges: one tree (*C. stricta*) and two shrubs (*C. muellerana* and *C. striata*). The shrub species are commonest in the wetter areas on infertile soils, while the tree species is characteristic of the drier facies of woodland and open-forest. With increasing moisture tall eucalypts become prominent. With decreasing moisture mallee eucalypts replace *C. stricta*. A further tree species, *C. cristata*, is very widespread in 'low woodland' on the dry side of the mallee formation in the Murray Plains. I tried to use pollen size to separate species, but found that this was of limited value because the range of size of the fossil pollen was considerably wider than that of the present-day species sampled. At the present time *C. stricta* is common on

TABLE 2

*Pollen present on ten slides from layers 3, 5, 6 and 7 (commonest forms only listed and expressed as totals and %).*

| Layer | 3 | | 5 | | 6 | | 7 | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| *Casuarina* | 315 | 32 | 398 | 51 | 244 | 50 | 24 | 15 |
| Compositae 1a | 89 | 9 | 42 | 5 | 24 | 5 | 30 | 6 |
| 1b | 48 | 5 | 4 | <1 | 6 | <1 | | |
| 2 | 21 | 2 | 2 | <1 | 1 | <1 | 3 | 2 |
| Chenopodiaceae | 44 | 4 | 10 | 1 | 31 | 6 | 8 | 5 |
| Haloragaceae | 58 | 6 | 22 | 3 | 13 | 3 | 6 | 4 |
| Gramineae | 22 | 2 | 19 | 2 | 19 | 4 | 9 | 6 |
| *Banksia* | 37 | 4 | 9 | 1 | 2 | <1 | 3 | 2 |
| Myrtaceae | 6 | <1 | 2 | <1 | 1 | <1 | — | — |
| Spores | 24 | 2 | 14 | 2 | —* | —* | 3 | 2 |
| Unknowns | 343† | 35 | 248 | 33 | 143 | 30 | 94‡ | 60 |
| Totals: | 1011 | | 770 | | 484 | | 160 | |

* Spores were found in this layer but not on the slides counted.
† Probably included *Casuarina* and *Myriophyllum* grains too poorly preserved to identify accurately.
‡ Probably largely Cyperaceae and Juncaceae.

the rocky slopes around the study site, and the simplest interpretation of the pollen record is that a similar type of woodland persisted throughout the period represented by layers 7 to 3. However, the contribution of *Casuarina* to a pollen assemblage is usually out of all proportion to its importance in a mixed stand of trees, so that its apparent dominance of the local tree flora 8000 years ago should not be taken as proven.

Two *Banksia* species are found in South Australia. Both are largely restricted to areas with rainfall in excess of 400 mm per year. *B. marginata* is widespread in the Mt Lofty Ranges, and is known near the study site, whereas *B. ornata* is of more local occurrence in this part of the State, and is not known near the study site. The pollen size of the two species appears to be significantly different (Cookson & Erdtmann 1952), *B. marginata* averaging 34 μm and *B. ornata* 58 μm. My fossil material compared closely with *B. marginata*, an average of 38 μm was obtained for 12 grains. It seems likely that the pollen is largely from *B. marginata*-type plants. Unlike *Casuarina*, *Banksia* is a poor pollen-producer, and the relative abundance of *Banksia* pollen suggests that the genus was locally common.

The family Myrtaceae, an important family because of its dominance of much of the Australian tree flora, is represented by a remarkably low pollen count; eucalypts are now by far the most common trees in the area within a few kilometres of the site. The Myrtaceae pollen in the deposit seems to be mostly from eucalypts, and to represent a number of species. Eucalypts now locally dominant are known to have high pollen yields (Boomsma 1972) and, in view of the current close proximity of the trees to the site, one would have expected a more obvious record of their presence.

Chenopodiaceae, Compositae and Gramineae are all now found in 'woodland to open forest with an herbaceous understorey' (Specht 1972). The importance of the fluctuations in number of each group is obscure. Pollen from low shrubs such as *Acacia* and *Pimelea* are also present.

'Unknowns' play a prominent part on the pollen counts. The majority of these pollen were probably Cyperaceae and Juncaceae with possibly some Gramineae, which would be consistent with a valley-bottom sedge and rush community. *Typha*-type pollen were noted in very large numbers in layer 6 and, if this identification is correct, it seems likely that this species colonized the site for a relatively brief period, presumably because local conditions were suitable for its establishment. Whether this was a chance occurrence or dependent on certain specific ecological factors is uncertain.

It seems likely that the Haloragaceae pollen recorded consistently from each layer is *Myriophyllum*, a genus found locally with several aquatic or marginally aquatic representatives. This would be consistent with results found from other sites of similar age from southeastern South Australia. Dodson (1974a, 1974b, 1975) noted persistent high counts for *Myriophyllum* pollen in his material from Lake Leake, Marshes Swamp and Mt Gambier.

The precise identification of the different types of spores has yet to be realized, but there are probably at least 10 species in the deposit. A number of these are fern spores lacking a perispore with affinities to *Cheilanthes* and *Lindsaea*. Two other spore-types were identified as Anthocerotales, a group found occasionally in damp areas higher in the Mt Lofty Ranges but not now found in the Palmer area.

Two *Lycopodium* spores were also noted, although they could not be positively identified as being from one of the species now found in South Australia (*L. deuterodensum*, *L. laterale* and *L. serpentinum*). This genus now has a very restricted distribution in the state, and is found only at a few sites such as Square Water Hole, Mt Compass and the Mt Lofty Summit Swamps, all places with permanent standing water.

## Discussion

It has been established by others that the climate in southern Australia has been relatively stable over the past 10 000 years; temperature and rainfall are thought to have been marginally higher between 8000 and 5000 years B.P. than now, and this spell was apparently followed by a drier period around 3000 years B.P. before it became wetter again (Bowler *et al.* 1976).

It appears that the generic content of the vegetation at Gorge Creek has remained largely unchanged over the last 8000 years. *Casuarina*, *Banksia* and *Eucalyptus* formed the most prominent pollen-contributing genera 8000–6600 years ago. An understorey of herbs and subshrubs (chenopods, composites and grasses) was present around a shallow lake or waterhole with Cyperaceae and *Juncus* species near the water's edge. In the pool grew *Myriophyllum*, *Potamogeton* and several other hydrophytes. On nearby slopes, possibly among rocks, were established a few ferns, Anthocerotales and possibly *Lycopodium* species. Only the Anthocerotales and *Lycopodium* species are no longer found locally.

The major plant families at this site are also the commonest families noted by Dodson (1974a, 1974b, 1975) and by Dodson & Wilson (1975) at five sites in southeastern South Australia and southwestern Victoria. All of the Victorian sites are in areas dominated by woodland or open-forest and, although the relative importance of the major floristic groups varies quite considerably, it is clear that the pattern of vegetation at this site is closely comparable with that at sites in the southeast. It is quite different from that found by Martin (1973) in material from Nullabor Caves where the present rainfall is about 200 mm per year; chenopods dominated her pollen counts, while Compositae, Gramineae and Myrtaceae accounted for most of the rest of the pollen.

Pollen analysis shows little change in the generic content of the four layers examined. The presence in quantity of the *Typha*-like pollen in layer 6 would appear to be a local phenomenon, a chance occurrence made possibly by some change in the local environment. Fluctuations in climate were apparently not great enough to cause significant changes in the vegetation, although pollen-containing sediments represent only a small part in the history of the sediments.

It appears that the onset of a slightly drier climate (perhaps about 5000 years B.P. as discussed by Churchill 1968, and Bowler *et al.* 1976), possibly coupled with a step in the vegetational succession of the waterhole whereby it was no longer permanently wet but only seasonally swampy, meant that anaerobic conditions were no longer maintained, and any organic matter formed was no longer preserved to form obvious organic bands.

More recently wetter conditions have prevailed again, and the organic content of the sediments has increased, as some sort of ground cover, presumably largely Cyperaceae and *Juncus*, has been established and maintained, but conditions suitable for the formation of permanent standing water or the preservation of pollen have not re-occurred. Sands with a marked dark colouration have accumulated, but no peat.

One of the most interesting features of the deposit is the occurrence of spores of the Anthocerotales, a group which appears to be absent from the area now. Dodson (1974b) found an abundance of '*Anthoceros*' spores in material from about 8000 B.P. at Lake Leake, and there were noticeable peaks in the abundance of the genus at Marches Swamp and Blue Tea Tree Swamp about 7500 years B.P. (Dodson & Wilson 1975), and at Lake Keilambete about 6500 years B.P. (Dodson 1974a). It is tempting to suggest that the increase in importance of the Anthocerotales about 8000–5000 years B.P. may have been correlated with slightly wetter conditions. However, one species of Anthocerotales has been recorded in the Wyperfield National Park in western Victoria where the rainfall is about 300 mm per year (G. A. M. Scott, pers. comm.), and some species are known to develop tubers, and appear to be able to withstand drought (Goebel 1905). Until the spores can be more positively identified, and more is known about the distributions of the genera and species and the factors controlling their growth, one cannot use them as unequivocal evidence of climatic change.

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# GEOLOGICAL HISTORY OF THE MOUNT GAMBIER VOLCANIC COMPLEX, SOUTHEAST SOUTH AUSTRALIA

*BY M. J. SHEARD*

## Summary

The Mount Gambier Volcanic Complex comprises a close-knit series of composite maars with a complex history of eruption, the earlier date being 4720 ± 90 years B.P. Detailed field mapping has similarly revealed two main periods of eruption, each one comprising at least three phases of activity. Maars were the major volcanic structures produced; however, Strombolian and Icelandic eruptions are indicated by scoria cones and lava sheets.